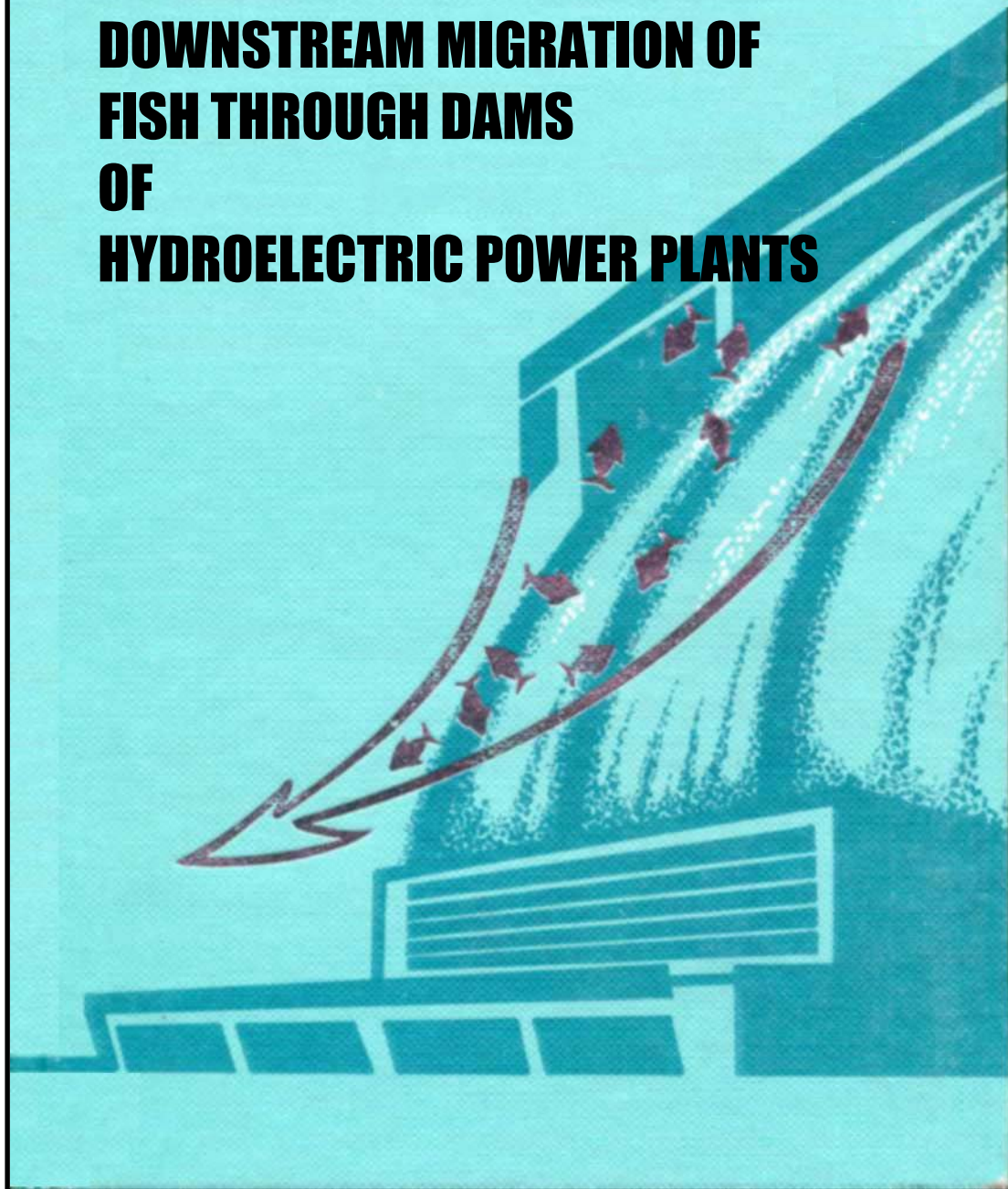


D. S. Pavlov, A.I. Lupandin, V.V. Kostin

**DOWNSTREAM MIGRATION OF
FISH THROUGH DAMS
OF
HYDROELECTRIC POWER PLANTS**



D. S. Pavlov, A.I. Lupandin, V.V. Kostin

**DOWNSTREAM MIGRATION OF FISH
THROUGH DAMS
OF
HYDROELECTRIC POWER PLANTS**

DOWNSTREAM MIGRATION OF FISH
THROUGH DAMS
OF HYDROELECTRIC POWER PLANTS

By D.S. Pavlov, A.I. Lupandin, V.V. Kostin
A.N. Severtsov Research Institute of Ecology and Evolution
Russian Academy of Science

Moscow-Nauka-1999

This book is a fundamental research in migration and it describes how the regulated river flows affect fish downstream migration. The book provides information on 45 reservoirs, and it contains a comparative analysis of patterns (species and sizes of the downstream fish migrants, as well as seasonal and daily dynamics of their migration) and migration mechanisms through dams of hydroelectric power plants (HPPs). It has been shown that the major factor affecting fish downstream migration is the influence of the water intake. The book gives data on fish injuries at their passage through the HPP turbines.

The book is intended for ichthyologists, those who deal with the protection of fish resources, as well as for hydroelectric and hydrotechnical engineers and fish industry experts.

Forward to the English Edition

Russian scientists have been contributing to the understanding of hydropower effects on fish populations for decades, but many of their publications have not been readily available to the international research community. This translation has been produced to help address that problem.

In this book, originally published by Nauka Press in Moscow in 1999, the authors summarized and integrated years of work in European and Asian river systems and the efforts to understand how regulated river flows affect downstream movements of fish. They summarized considerable literature on the ecological preferences of fish (especially juvenile fish) in Eurasian reservoirs and categorized species by habitat zones. The book considers the patterns, causes, and mechanisms for downstream movements, and it assesses the susceptibility of fish to loss from the reservoir, as a function of species, life stage, habitat zone preferences, and characteristics of the reservoir. Lastly, the book describes the effects of turbine passage and techniques to mitigate turbine-passage losses of fish.

I have endeavored to retain a literal translation of the text. Thus, two terms warrant explanation. Foremost is the term “migration.” To many fisheries biologists, “migration” connotes long-distance, purposeful movements, and is most commonly used with reference to movements of diadromous fish. The authors appropriately use the term in a more general sense to describe active or passive movements of fish within and out of reservoirs. In the context of the resident fishes that are the subject of most of the studies summarized in this book, the term “migration” is more likely to mean the unintended loss of resident fish from the reservoir than the volitional downstream movements of juvenile anadromous fish. Similarly, their frequently used term “reservoirs with slow water exchange” is akin to our terms “slow turnover rate” and “slow flushing rate.”

One of the many values of this book is that it provides information about Eurasian fish species that may be unfamiliar to fisheries scientists in North America. In translating the Russian common names of fishes to English, I have relied on the FishBase database [Froese, R., and D. Pauly, eds. 2001. FishBase. World Wide Web electronic publication (<http://www.fishbase.org>). Accessed 8 February 2002.]

I would like to express my appreciation to others who have helped bring this book to a wider audience. D. S. Pavlov, A. I. Lupandin, and V. V. Kostin graciously agreed to our translation and distribution of their work. Tatyana Albert provided the original translation, and Carolina Ravina helped refine it, both through her own skills and by consulting with the authors. Peggy Brookshier and John Flynn of the U.S. Department of Energy’s Hydropower Program recognized the value of this information and this effort. The responsibility for any errors in the translation of this book is mine.

Glenn F. Cada, Ph.D.
February 2002

Suggested Citation:

Pavlov, D. S., A. I. Lupandin, and V. V. Kostin. 2002. Downstream Migration of Fish Through Dams of Hydroelectric Power Plants. Trans. T. Albert, trans. ed. G. F. Cada. ORNL/TR-02/02. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Available on-line from the U.S. Department of Energy Hydropower Program
[<http://hydropower.id.doe.gov/>] and on CD from:

Glenn F. Cada, Environmental Sciences Division, Oak Ridge National Laboratory,
P.O. Box 2008, Oak Ridge, TN 37831-6036, U.S.A.

TABLE OF CONTENTS

FORWARD TO THE ENGLISH EDITION	I
INTRODUCTION	7
Chapter 1 REGIONS OF RESEARCH, MATERIAL AND METHODS	12
1.1 Brief Description of Studied Reservoirs	12
1.2 Characteristics of Studied HPP Dams	17
1.3 Methods for the Study of Downstream Migration and Fish Distribution	19
1.4 Scope of Collected Material	24
Chapter 2 FISH DISTRIBUTION AND ECOLOGICAL ZONES OF WATER INTAKE	26
2.1 Ecological Zones of Reservoirs with Slow Water Exchange	26
2.2 Fish Distribution in Reservoirs	28
2.3 Procedure for Estimating the Ecological Zones of Water Intake	44
2.4 Estimation of Ecological Zones of Water Intake Based on Studied HPP Intakes	48
2.5 Relationship between Downstream Migration and Fish Distribution	52
Chapter 3 PATTERNS OF FISH DOWNSTREAM MIGRATION THROUGH HPP DAMS	53
3.1 Species-Specific Structure of Migrants	53
3.2 Age and Size Structure of Fish Migrants	60
3.3 Quantitative Characteristics of Fish Downstream Migration	68
3.4 Daily Dynamics of Fish Downstream Migration	71
3.5 Seasonal Dynamics of Fish Downstream Migration	79
Chapter 4 CAUSES AND MECHANISMS OF FISH DOWNSTREAM MIGRATION FROM RESERVOIRS WITH A SLOW WATER EXCHANGE	90
4.1 General Theoretical Aspects of Mechanisms of Downstream Migration of Young Fishes	90
4.2 Fish Entrainment in the Water Intake Zone	102
4.3 Migratory Fish Behavior in Water Intake Zone	106
4.4 Major Factors of Fish Migration from Reservoirs with Slow Water Exchange and Their Mechanisms	116
4.5 Model for Fish Downstream Migration from Reservoirs	125
Chapter 5 FISH INJURIES AND LOSSES FROM PASSAGE THROUGH HPP TURBINES	137
5.1 Kinds of Fish Injuries on Passage Through the HPP	138
5.2 Types of Turbine Designs and Factors Affecting Fish Injuries and Death at HPP	142
5.3 Pressure Change as One of the Causes of Fish Loss and Injuries at Turbine Passage	145
5.4 Cavitation Effect on Fish Injuries and Fatalities at Turbine Passage	159
5.5 Turbulence as a Factor of Fish Injuries and Fatalities in HPP Turbine Penstock	162
5.6 Fish Injuries Resulting from Contact with Structural Components of the Turbines	168
5.7 Comparison of the Effects of Various Factors to Fish Injuries and Losses During Their Downstream Migration	174
Chapter 6 APPROACHES TO PROTECTION OF MIGRATORY FISH	187
6.1 Parameters of Fish Losses at HPP Dams	187
6.2 Effect of Fish Losses on Fish Populations in the Reservoirs	191
6.3 Strategies for Fish Protection at HPP Dams	193
6.4 Principles of Fish Protection	195
6.5 Methods of Fish Protection	196
CONCLUSION	202

ATTACHMENT	205
Ivan'kovskoe Reservoir.....	205
Ust'-Khantajskoe Reservoir	209
Sheksninskoe Reservoir.....	212
Ozeminskoe Reservoir	215
Kapchagajskoe Reservoir	217
Mostiste Reservoir.....	220
Volgogradskoe Reservoir	223
Al. Stambolijski Reservoir	225
Nurekskoe Reservoir	228
 BIBLIOGRAPHY	 229